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ABSTRACT

The authors' activities in co-teaching an engineering design course across the Atlantic, at Carnegie Mellon University (CMU), USA, and at Delft University of Technology (DUT), the Netherlands, at the same time, required the use of information and communication tools for communication and collaboration purposes between students and between instructors and students. This paper analyzes the overseas communication and collaboration processes among students and instructors, and their implications for learning. A theoretical framework was used for collaborative learning and for stimulating active participation, for analyzing observations and for translating results to a broader theoretical framework. In practice, it meant that the authors experimented among other variables with group compositions and with instructor role descriptions. It is concluded that many of the techniques mentioned in literature did enhance collaboration and learning between students, but that intense communication with overseas instructors is still a major stumbling block. (Contains 10 references, 2 tables, and 5 figures.) (Author)

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Communication and Collaborative Learning in a Cross-Atlantic Design Course

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Abstract: Our activities in co-teaching an engineering design course across the Atlantic, i.e., at Carnegie Mellon University (CMU), USA and at Delft University of Technology (DUT), the Netherlands, at the same time, required the use of information and communication tools for communication and collaboration purposes between students and between instructors and students. In this paper we analyze the overseas communication and collaboration processes among students and instructors, and their implications for learning. We have used a theoretical framework for 'collaborative learning' and for 'stimulating active participation' for analyzing our observations and for translating our results to a broader theoretical framework. In practice, it meant that we experimented among other variables with group compositions and with instructor role descriptions. We concluded that many of the techniques mentioned in literature did enhance collaboration and learning between students, but that intense communication with overseas instructors is still a major stumbling block.

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1 Introduction

The availability of various information and communication technology tools (ICT) has enticed many experiments that are aimed at evaluating the use of ICT tools in university courses. Our activities in co-teaching an engineering design course across the Atlantic, i.e., at Carnegie Mellon University (CMU), USA and at Delft University of Technology (DUT), the Netherlands, at the same time, also required the use of ICT tools for communication and collaboration purposes between students and between instructors and students.

In earlier papers (Herder *et al*, 2002; Subrahmanian *et al.*, 2001) we have reported on the use and effectiveness of tools like video conferencing and video taped lectures in the course. In this year's edition of the course we have focused on communication between students and instructors and on the role(s) of the instructors on both sides of the Atlantic. The experiments in this course are part of a large project executed at DUT, in which various instructors research the functional use of ICT in their courses (Brakels *et al.*, 2002).

The main objective of the course "Engineering Design Problem Formulation" is to teach the process of engineering design problem formulation and the role of mathematical and other modeling techniques to aid in that formulation. The pedagogical objective is to get the students to understand that articulating the right problem, based on a process of negotiation and clear representation of the problem among the stakeholders and the design team, is more important than being able to solve perfectly the wrong problem (Subrahmanian *et al*, 2001). The reason for involving students from the USA as well as from the Netherlands was that by doing so, we were able to use a "constructivist approach" to learning: showing the students that knowledge is not developed in isolation but within a social and cultural context (Brown and Duguid, 2000; Fetherston, 2001).

First, we ask groups of students to formulate a number of small design problems, to become familiar with the use of the basic framework of goals, tests, design spaces and starting points and with the use of mathematics as a language for articulating and unambiguously representing a problem. The groups are mixed groups in the sense that they include students from DUT as well as from CMU. Once they are reasonably familiar with this way to recast problems, we step up to larger group-based assignments. They are asked to read and report on books from a list we provide in the area of engineering and design. The students were to analyze the design exemplars in the books and characterize them by using the four-part description we present to aid in formulating design problems. The final, large assignments include design problems, such as design of a transportation system for Pittsburgh and the design of a water/sewage system for a new housing development near Amsterdam.

In this paper we analyze the communication and collaboration processes among students and instructors. The next section will describe the theoretical framework that we will use to analyze our results. During the course, we have experimented among other variables with group compositions and with instructor role

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descriptions, which will be described in the next section. The results describe our experiences with on-line participation and on-line learning, based upon a survey we held among the students after the course and based upon on our observations during the course.

2 Research Model and Approach

2.1 Introduction to the Course as an Electronic Conference

The course described in this paper required on-line communication because of distance (USA and Europe) and time difference (six hours) between the two groups of students and instructors. Based upon our experiences from running last year's course (Herder *et al*; 2002, Subrahmanian *et al* , 2001), in which our efforts focused on the technicalities of the use of ICT tools in teaching, we decided this year to focus on the collaboration and communication aspects between the groups and instructors. In particular, we ran the different elements of the course in different ways.

The course required students to work on formulation problems *together* by discussing the problems, posing questions to each other, critiquing and commenting each other's work, sharing the workload and decreasing the project's run time by 'leap-frogging', i.e., half of the group works while the other half of the group is out-of-office - the second half continues the work when the first half is out-of-office, etc. All communications, reports, comments and the like were to be posted in the web-based document management system LIRE' (*n*-dim group, 2001) so that all information would be retrievable for anyone at any time. This type of on-line collaboration and interaction is often referred to as a computer mediated conference (CMC).

Salmon (2000) developed a five-stage model for on-line learning and moderation of electronic conferences, which we will use in this paper as our research framework. The consecutive stages defined by Salmon are: (1) Access and Motivation, (2) Socialization, (3) Information Exchange, (4) Knowledge Construction, and (5) Development and Reflection.

For each of these steps it is important to focus on the *technical* issues, the *mutual learning* issues and the *E-moderating* issues. The technical issues have been described in our papers mentioned earlier, and we refer to those papers for the conclusions. This paper focusses on the other two issues in the five stage model, i.e., the learning issues (student - student interaction) and the E-moderating issues (student - instructor interaction). Steps three and four from the five stage model will be worked out in detail in this paper. Table 1 shows some brief previous results and implementations for the steps and issues that are not being discussed elaborately in this paper: the *technical* issues for all steps are summarized in the second column, and the *learning* and *e-moderating* issues are summarized in the two righ hand side columns for steps one, two and five.

Table 1. Application of the five stages (Salmon, 2000) to the course (bold typeset is discussed in this paper).

	Technical[1]	Learning	E-moderating
1. Access & Motivation	Communication tools	Personalities and	On-line course material
2. Socialization	Video conference	group formation[1]	User instructions[1]
3. Information Exchange	Web Based Document	**Collaborative**	**Stimulating active**
4. Knowledge Construction	Management System	**learning**	**particpation**
5. Development & Reflection	Video clips	Evaluation & Survey[2]	

1) See, for example, Herder *et al.* (2002)
2) Executed in a face-to-face meeting

Salmon (2000) provides some advice relevant to each of the five stages. Other authors, however, provided more in-depth advice on how to stimulate collaborative learning and active participation. In particular, we have used the techniques proposed by Hiltz (1994) to stimulate active participation and collaborative learning. These techniques are briefly summarized in the next two sections.

2.2 Collaborative Learning

The ultimate goal of taking a course is to gain knowledge or learn new skills. Particularly in a course where group work is key, collaborative learning is probably dominant over traditional one-to-many learning from instructors. In order to get students to (collaboratively) learn the skills and knowledge they are required to learn, it is imperative that some techniques are being applied that support and encourage collaborative learning and student to student interaction. We have turned to Hiltz (1994) for a number of concrete collaborative learning formats and assignments. The ones that we used in the course are: students as teachers, writing groups, group or team projects, and team building.

2.3 Stimulating Active Participation

Any conference or discussion requires a moderator who is able to stimulate participants to actively participate in the discussions. For computer mediated conferences the issue is even more significant, as the moderator and participants are not in direct contact with each other. Hiltz (1994) suggests a number of techniques that may stimulate participants to engage into electronic conferences, some of which we have applied in parts of our course. The techniques used in the course in the instructor-student communications are "require regular participation," "instructors present conflicting opinions," "responding and weaving by instructors," "explicitly request responses," and "role playing."

2.4 Research Variables and Approach

Our experiences in running the course last year indicated that we needed to provide the students from the outset with some *basic* instructions about how to communicate effectively with people at a distance and with a time lag. Instead of letting each group 'invent the *communication* wheel' all over again, we pointed them toward the various opportunities besides emailing, such as chatting, telephoning or even video-conferencing.

Table 2. Application of techniques in the course.

	Assignment 1	Assignment 2	Assignment 3
Collaborative learning			
students as teachers			X
writing groups	X	X	X
group projects	X	X	X
team building		X	X
Active participation			
require participation	X	X	X
conflicting opinions			X
responding / weaving	X	X	X
request responses			X
role playing			X

Table 2 shows the techniques we applied in the various stages of the course. For the first small assignment in the course, we dropped the students in at the deep end of the pool with respect to getting the overseas cooperation to work. We provided them with basic technical support and with conventional instructor support. As the course progressed, instructions and structure became increasingly unambiguous by applying more and more techniques for collaborative learning (student-student communication) and active participation (student-instructor communication).

The following sections describe our specific implementations and experiences with the various techniques. The impacts on the learning and collaboration process have been measured by distributing a survey after the course and by evaluating the course with the students in a face-to-face meeting. Our personal observations were used with caution as a third source of information.

3 Collaborative Learning

The course was taught simultaneously at both locations by two instructors at each side during fall 2001. We were able to re-use the schedule and material (lectures, handouts) that we developed in fall 2000 when we ran the first experiment of this course. A total number of 24 students participated in the course (6 at DUT and 18 at CMU). The students were instructed about the basics on cross Atlantic cooperation in the first class, comprising communication tools and etiquette. The survey indicated that the methods for communication were reasonably clear at the start of the course, as indicated in figure 1. It shows the *number* of students that agreed or disagreed on the statements in the survey, using *scores* on a 1 (disagree) - 5 (agree) scale.

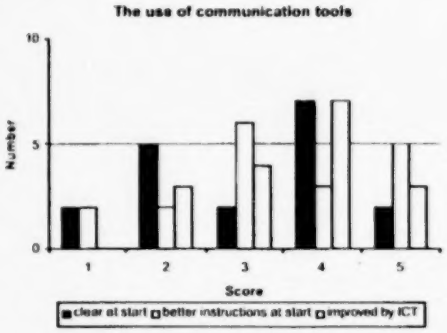

Figure 1. Communication tools in the course.

Cross-Atlantic collaboration was initiated for the first assignment by doing *group work* - groups based on personality tests of the students (Meyers-Briggs test, 2001) that spanned the two participating universities - and by forming *writing groups*, i.e., letting the students critique each other's intermediary work and reports. Some students indicated that they felt disconnected from the students at the other side of the Atlantic because they only knew each other from electronic communications. Other students divided the group work such that they had to communicate with each other as little as possible. Only towards the deadline of the first assignment, the students reformed into writing groups to critique each other's work.

In order to enhance the communication and collaboration in the groups we asked the students to form the groups for the second assignment themselves, resulting in better *team building* (Hiltz, 1994). All groups managed to cooperate more intensely on the book reports, and in most cases the reports were reviewed and critiqued by all group members. For the third assignment the groups were reshuffled again and we explicitly asked the students to present new or complex aspects of their work on the assignment in class to the other students. In addition, they were asked to pose questions to the other students. The *students* became *teachers*, which further enhanced collaborative learning in and between the groups.

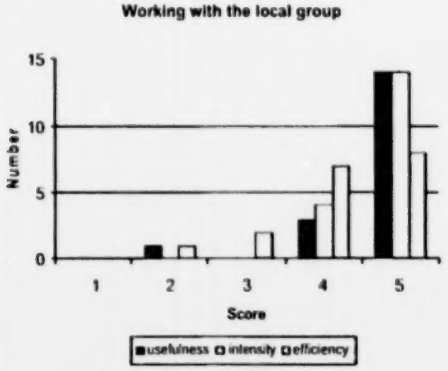

Figure 2. The usefulness, intensity and efficiency of local collaboration as compared to international collaboration.

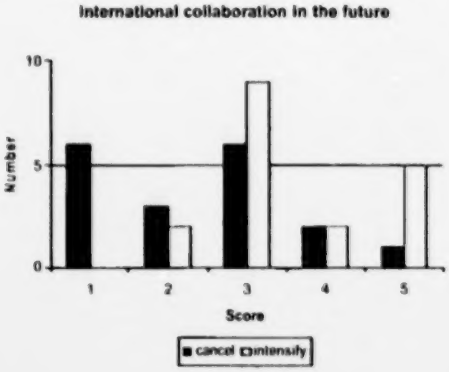

Figure 3. Students' opinions on international collaboration for future courses.

The students were asked to rate the usefulness, intensity and efficiency of the overseas collaboration compared to the collaboration with local group members. As expected from theory and observations, the results in figure 2 indeed show that local collaboration was more useful, intense and efficient. Figure 3 shows that, despite the difficulties of international collaboration shown in figure 2, the students would still rather intensify the international collaboration than cancel it.

The students were found to spend an average of 2,5 hours per week in emailing with each other, in addition to over 1 hour per week of on-line chatting and over 1 hour per week of using LIRE'. The telephone and the video clips available were used only a couple of minutes per week on average.

4 Stimulating Active Participation

The first student assignment comprised two small formulation problems. The instructors were given no specific roles other than to quickly answer questions and to teach a number of regular classes. The group assignments were mandatory and any results were to be posted into LIRE', thereby *requiring participation*. Students tended to consult their local instructor primarily and left the coordination of instructors' advice and responses to the instructors. Topics that appeared to be relevant for all the students were discussed or communicated plenary by the instructors to all students (*responding and weaving*).

For the third assignment we decided to boost active participation by applying a number of extra techniques. The instructors were given *specific roles* with particular objectives that would *conflict* with other instructors' objectives. More specifically, the students were the project contractors, one instructor was given the role of project commissioner for the design problem, while the second instructor overseas played the role of one of the stakeholders with possibly conflicting objectives. For example, we added an environmental lobbyist as a stakeholder to the design of a disposal method for an oil rig (commissioned by a fictitious oil company). Finally, we required the students to send weekly progress reports to the *overseas* instructors. By explicitly *requesting responses*, we expected that instructor-student interaction and active participation would be enhanced even further. However, the students never managed to send a progress report to any instructor, indicating that our response request did not fit their specific activities or needs. We did observe that more frequent contacts occurred between instructors (local as well as overseas) and students in the final assignment compared to the first two assignments.

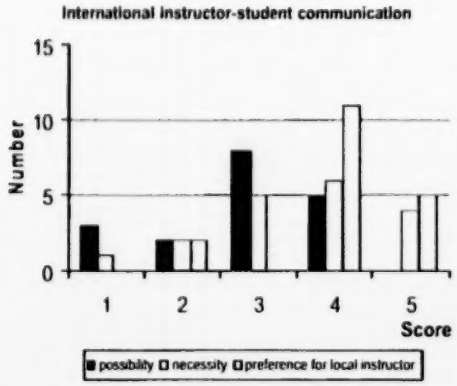

Figure 4. *The possibility, necessity and preference with respect to communication with the international instructor.*

Figure 5. *Preference of students on the roles of instructors in the large assignment.*

The results shown in figures 4 and 5, confirmed our hypothesis of international instructor-student communication: although the international communication is necessary and feasible, the students still prefer to communicate with a local instructor. This confirms results obtained by Walkington and Maroulis (2001), who

found that social presence and meaningful relationships between instructors and students are crucial for sound pedagogy, but are very hard to achieve in CMC activities. Although the role playing technique may have had the effect we aimed at, i.e., more intense communications between the two sides of the Atlantic, the opinion of the students about the role playing in the final assignment is indistinct, rendering that technique debatable for application in a cross Atlantic design course.

5 Conclusions

We have used the framework developed by Salmon (2000) to identify two important areas for improving the cross Atlantic design course, taught for the second year in an international setting. A number of techniques for these two areas, i.e., stimulating active participation and collaborative learning, were taken from Hiltz (1994) and were gradually incorporated into the course.

We found that the techniques for *collaborative learning* in a CMC environment contributed to a smoother learning process, although they did not take away fully the stumbling blocks for international cooperation. Students indicated that an intensification of international collaboration was desirable, if and only if this would be supported by appropriate communication tools, aimed at the contents of the work, but also on the social interaction between the students.

Techniques that we used to enhance *active participation*, mainly techniques applied by instructors, were found to be successful, except for the role playing technique. Our rationale for assigning roles to instructors was that we expected it to form an incentive for boosting communication between students and instructors from overseas. Students, however, preferred to talk to their "own" instructors, after which they relayed the messages to their overseas colleague students if necessary. Communication between the students was nevertheless increased which may have enhanced collaborative learning.

General comments from the students after the course have been encouraging. Most students indicated that they found the international course an interesting experiment. We should, however, increase their access to communication means that allow more social interaction than email and CMC alone. Many of the techniques we only gradually incorporated into the course this year, will be used from the beginning of the course next year.

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